

## **How to Prevent Ureteral Injuries during Pelvic Gynecological Procedures**

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### **Abstract**

Pelvic surgery is the most common cause of iatrogenic ureteral injury. The majority of patients with ureteral injuries have no identifiable predisposing risk factors. A simple maneuver that facilitates the identification of the ureter is described. When injury is discovered during surgery, correction of the injury can be repaired with minimal risk of long-term sequelae. Postoperatively, patients with ureteral injury typically present with costo-vertebral angle tenderness, ileus, fever, and flank pain with a minimal rise in serum creatinine. To prevent ureteral injuries, the surgeon must have a thorough knowledge of the location of the ureter during various pelvic procedures and the specific regions where it is most susceptible to injury. Ureteric stenting, when possible, offers a safe primary management of bilateral ureteric injury at radical hysterectomy, and gives in many cases, a definitive treatment and avoids further extensive and challenging procedures. Inspection of the bladder and ureteric orifices following surgery should detect any injury to the bladder and confirm ureteric patency. Routine operative cystoscopy allows the early diagnosis and repair of bladder/ureteric injury to avoid additional surgery, and the development of urinary fistulae and possible loss of renal function.

**Keywords:** Ureteral injury, abdominal hysterectomy, diagnosis, treatment, prevention.

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The incidence of urinary tract injury is low in most gynecological operations but, iatrogenic ureteral injury is not uncommon; it is a well-recognized complication of abdominal hysterectomy occurring in 5-30% of cases.(1-2) In particular, 75% of all ureteral injuries occur during gynecologic surgery, with the majority of these injuries occurring during abdominal procedures [3]. Bilateral injuries are rare.

Previous studies have reported a 0.4% to 2.5% rate of injury during benign pelvic surgery and only a third of these injuries were recognized at the time of surgery [4]. If undiagnosed, it is a cause of significant postoperative morbidity for the patient and litigation for gynecologist. The management of ureteric injury presenting during and following radical gynecological surgery has been frequently discussed in the literature although the evidence base for such management is restricted to expert opinion, with reports of long-term outcome lacking [5-8].

Furthermore, it must not be forgotten that pelvic surgery such as radical hysterectomy can affect lower urinary tract function, typically by injury to the pelvic nerves, resulting in a proportion of women experiencing long-term bladder dysfunction [9].

Even though the risk of injury is significantly higher in surgeries involving invasive cancer and urogynecologic procedures, all pelvic surgeons must become familiar with the causes and risk factors associated with this preventable complication. In this article, we reviewed the anatomic considerations, etiologic factors, risk factors, clinical presentation, prevention, and management of ureteral injuries sustained during abdominal hysterectomy.

## 1 Anatomic Considerations

To prevent injury to the ureter, the pelvic surgeon must become familiar with the anatomic features of the ureter and areas where it is most susceptible to trauma. Ureters are retroperitoneal tubular structures measuring approximately 25 to 30 cm in length, extending from the renal pelvis to the urinary bladder [3, 10-12]. The right ureter is approximately 1 cm greater in length than the left ureter. The abdominal portion of the ureter lies on the anterior surface of the psoas muscle, descending postero-laterally as it crosses over the iliac vessels. The right ureter contacts the descending portion of the duodenum anteriorly, running along the right aspect of the inferior vena cava. The left ureter lies posterior to the left colic vessels and passes posterior to the mesentery of the sigmoid colon. As the ureter approaches the pelvis, it is crossed anteriorly by ovarian vessels. The right ureter enters the pelvis by crossing over the external iliac artery while the left ureter crosses over the common iliac artery. At this point, the ureter lies medial to the branches of the anterior division of the hypogastric artery and lateral to the peritoneum of the cul-de-sac. At the mid-plane of the pelvis, the ureter is crossed anteriorly by the uterine artery. Here it tunnels into the cardinal ligament, approximately 1.5 to 2.0 cm lateral to the cervix near the internal cervical os and vaginal fornices as it enters into the trigone of the bladder. [10] Histologically, the ureter is composed of three concentric layers that include an inner layer composed of transitional epithelium, a middle layer of circular and smooth muscle, and an outer layer of adventitial sheath [3, 10-11]. The adventitial layer contains the arterial supply, nerve supply, and lymphatics of the ureter. Thus, it is important to maintain the integrity of the adventitial sheath during dissection of the ureter. To prevent ischemic injury to the ureter, one must also become familiar with its unique blood supply. The renal artery, ovarian artery, common iliac

artery, and the aorta all contribute blood supply to the ureter. In the abdomen, the ureter derives its blood supply from small arteries approaching it medially, whereas the pelvic ureter receives its blood supply from vessels approaching laterally [3, 10]. Because the vessels interface with the peritoneum, attempts should always be made to preserve the peritoneum with the ureter during dissection. Thus, the peritoneal incision to expose the ureter should be made laterally to the ureter in the abdomen and medially in the pelvis.

## **2 Cause of Injury**

Intra-operative injury to the ureter may result from ligation, angulations, transaction, laceration, crush, ischemia, and resection [11, 12]. The most common site of operative injuries to the ureter during routine abdominal hysterectomy or adnexectomy is at the pelvic brim, where the ureters lie beneath the insertion of the infundibulo-pelvic ligament. Other common locations are over the iliac arteries, within the cardinal ligament at the level of the internal cervical os where the uterine artery crosses the ureter, and at the antero-lateral fornix of the vagina as the ureter enters the bladder.

## **3 Risk Factors**

Although most (40%) ureteral injuries occur in patients who have no identifiable risk factors, there are certain conditions that increase the likelihood of ureteral injuries, particularly those that disrupt the normal anatomy and architecture of the ureters. These conditions include endometriosis, large ovarian masses, and pelvic inflammatory disease [13].

Pelvic malignancies appear to be a significant risk factor associated with ureteral injury. This is most likely related to the presence of tense adhesions, large masses that displace the ureter, and anatomic changes distorting the position of the ureters. Other risk factors include previous pelvic surgery, broad ligament fibroids, and history of pelvic radiation [14, 15]. Other less common factors that predispose a patient to ureteral injury include congenital abnormalities such as ureteral duplication, megaureter, and ectopic ureter or kidney. However, it is noteworthy that half of all ureteral injuries had no identifiable predisposing factors [13, 14]. In fact, the proximity of the ureters and lower urinary tract in pelvic surgery to the genital tract means that a urinary injury is always a possibility. Another factor to analyze is that the risk of injury of the urinary tract does vary with the type of surgery performed and the skill and experience of the surgeon. Not only is the type of surgery important but also how it is performed. Surgical experience must be an important factor not only in causation but also in recognition and adequate repair of the urinary tract injury.

## **4 Preventing Ureteral Injury**

The risk of urinary injury can be minimized by good surgical technique: having good surgical access and vision, knowing where the ureters and bladder are, and removing them from the surgical field when possible [16].

The best way to prevent injury to the ureter is to routinely identify its path through the pelvis and the regions where it is most susceptible to injury. The ureter must be identified through an incision that provides adequate exposure to prevent iatrogenic injury. The peritoneum is opened lateral to the infundibulo-pelvic ligament, and the ureter is identified on the medial leaf of the peritoneum. A simple maneuver [17] that facilitates the identification of the ureter involves the following steps. After dividing the round ligament near the lateral pelvic sidewall, the lateral peritoneum is opened 10 to 15 cm in a cephalic direction. An index finger is then placed on the external iliac artery, which can be identified easily from its superficial, consistent anatomic position and pulsating characteristics. If one then moves their finger upward, the first structure to be exposed, crossing and in contact with the iliac artery, will be the ureter. As the surgeon places an index finger on the ureter, the infundibulo-pelvic ligament should be behind the middle phalanx. In this manner, the infundibulo-pelvic ligament can be safely clamped with the ureter under direct visualization. The ureter is subsequently followed toward the cardinal ligament, where it passes under the uterine artery. If one needs to dissect the ureter away from harm, it is important to preserve the normal blood supply to the segment of the ureter found in the lower pelvis or on the level of the intra-vesical wall. Preservation of the mesentery to the ureter by carefully dissecting the ureter from the pelvic wall location while preserving its attachment medially to the peritoneum is recommended. This thin mesentery of fibro fatty tissue and small blood vessels contributes to the ureteral blood supply by branches from the hypogastric [18]. Although dissection or mobilization of the ureters may not be indicated, the ureters should be clearly identified in the abdomen or pelvis, particularly in areas where it is most susceptible to injury. To distinguish the ureter from other vascular structures, the ureter will typically elicit peristalsis on gentle stroking. Others have observed that the ureter has a characteristic snap when it is gently palpated [3, 10, 13, 19]. Previous studies have revealed that attention to the anatomic course of the ureter during pelvic surgery is more effective in preventing injury than preoperative intravenous pyelograms (IVP) or ureteral stent placements [20, 21]. The routine use of preoperative imaging of the urinary tract using ultrasound, intravenous pyelography, and computed tomography has not been shown to be effective or cost efficient in the prevention of urinary tract injury [22, 23]. Also, the routine use of ureteric catheterization in pelvic surgery to help identify and protect the ureter has not been shown to affect the rate of ureteric injury [24]. Although its usefulness is debatable, IVPs have been used preoperatively to locate the ureters for surgery in patients with disease processes that may distort the ureters, such as pelvic masses or inflammatory disease. Retrograde ureteral catheters, which are used to help identify ureters for dissection, were also found to have questionable value in the prevention of intra-operative ureteral injury; but Kuno et al [20] found that prophylactic ureteral catheterization did not eliminate the risk of ureteral injuries. Routine operative cystoscopy allows the early diagnosis and repair of bladder/ureteric injury to avoid additional surgery, and the development of urinary fistulae and possible loss of renal function. The major impediment to the more widespread use of routine cystoscopy has been the lack of training and familiarity of gynecologists with the cystoscope, how it is used, and whether what is seen is normal and abnormal. Gynecologists generally have had an excellent training in endoscopy and endoscopic equipment in the areas of pelvic laparoscopic surgery and genital endoscopy (e.g. hysteroscopy), so cysto-urethroscopy should be a natural extension of these skills. Clearly, the best defense against ureteral injury is meticulous surgical technique and identifying the course of the ureter and the associated anatomic locations where injury is

most likely to occur. During abdominal hysterectomy, the ureter can be visualized by opening the anterior leaf of the broad ligament. The ureter is surrounded by loose avascular fibro-connective tissue. Once exposed, the ureter is gently pushed laterally and downward, moving it away from the cervix. This maneuver protects the ureter and with traction on the uterus also exposes the uterine artery. However, endometriosis and/or pelvic inflammatory disease may disfigure the region where the ureter crosses the uterine artery at the mid-plane of the pelvis. Furthermore, large broad ligament or cervical leiomyomas may obscure the operative field, making the dissection extremely difficult.

## **5 Intra-operative Diagnosis of Ureteral Injury**

If ureteral injury is suspected intra-operatively, the surgeon must promptly identify the ureter and evaluate the severity and nature of the injury. If the injury cannot be adequately visualized, an intravenous injection of indigo carmine can help confirm and identify the location of the ureteral injury. If urine passed into the Foley catheter is blue, one can only be certain that one of the ureters has not been ligated. Furthermore, failure to visualize the passage of blue urine into the bladder via cystoscopy suggests occlusion of one or both ureters [25]. The standard methods of surgical management used for unilateral injury may need to be modified or used in combination for cases of bilateral injury and close observation is needed to minimize further loss of renal function and to avoid uro-sepsis. Routine operative cystoscopy allows the early diagnosis and repair of bladder/ureteric injury to avoid additional surgery, and the development of urinary fistulae and possible loss of renal function. Bladder injuries are more likely to be recognized at the time of surgery and repaired than ureteric injury if intra-operative cystoscopy is not performed.

## **6 Postoperative Clinical Evaluation.**

Ureteral trauma can be easily missed, particularly in the case of unilateral injury. If the contra lateral kidney is healthy, it will compensate for the loss with only a transient rise in creatinine [26]. Eventually the affected kidney will lose its function. Early postoperative diagnosis of ureteral injury typically takes place 7 to 10 days after surgery [3]. Symptoms include costo-vertebral angle tenderness, ileus, fever, and flank pain, indicating a hematoma, inflammation, or infection at the site of injury. An IVP and cystoscopy should be performed if ureteral injury is suspected to locate and characterize the injury. Because immediate dissection may be difficult, retrograde ureteral catheter placement and nephrostomy drainage may obviate the need for surgical intervention [11].

## **7 Treatment of Ureteral Injury**

The approach to ureteral repair depends on the cause, location, and extent of the injury. Minor trauma, such as ligature or crush injuries may be managed with stent placement and drainage of the affected area. Stents remain in place for approximately 6 weeks, followed by an IVP to ensure ureteral patency. In particular, ureteric stenting, when possible, offers a safe primary management of bilateral ureteric injury at radical

hysterectomy [27]. In fact, despite the ureters being identified and protected during the dissection, it is easy to severely compromise the blood supply, leaving a devascularised segment which then stenoses and ruptures in the immediate postoperative period. This mechanism of injury explains the delayed presentation of this damage. Ureteric stenting has the advantage of stabilizing the situation, protecting renal function, and drying up the vaginal leakage, whilst the patient recovers from the primary surgery. The potential disadvantage exists however of needlessly delaying definitive open repair. Vigilance is required to detect silent ureteric stenosis in the longer term, which may threaten remaining renal function [28]. Open surgery can therefore be reserved for the case where stenting fails or for later management of persistent distal ureteric strictures or when ureteric injury present in the postoperative period particularly when faced with uretero-vaginal fistula [29]. In these cases, the use of ureteric stenting as a primary maneuver is amassing an increasing volume of suppurative evidence [8].

Partial transections are typically corrected by suture repair or resection of the affected segment. Clearly, damage to a greater portion of the ureter requires a more involved repair. A crush injury or transection in the middle portion of the ureter can be repaired by an end-to-end anastomosis [3, 26]. To ensure a tension-free anastomosis, it may be necessary to free the ureter from its peritoneal attachments or by mobilizing the kidney. Also, a psoas hitch can add several centimeters of length to the ureter. In this procedure, the bladder is sewn to the psoas tendon and the ureter is reimplanted through a sub mucosal tunnel into the bladder. Injuries near the bladder can be repaired by direct implantation of the ureter into the bladder or through a sub mucosal tunnel; the latter technique is less likely to be associated with vesico-ureteral reflux. Injuries in the middle or upper third of the ureter can be repaired by an uretero-ileo-neocystotomy, where a bridge between the ureter and the bladder is made from a segment of the terminal ileum.

## 8 Outcomes of Ureteral Injury

Minor injuries to the ureter can be reversed intra-operatively without any long-term sequelae. However, necrosed segments of ureters can lead to a weakened ureteral wall, resulting in extravasation of urine into peri-ureteral tissues. An urinoma may develop, which can become infected and lead to an abscess. Alternatively, urine can accumulate in the peritoneal cavity leading to urinary ascites and peritonitis [26]. Uremia typically results from damage to both ureters. Bilateral ureteral ligation presents as anuria during the first 24 to 48 hours in the postoperative period and later develop a rise in blood urea nitrogen and creatinine levels. Immediate urinary drainage, through nephrostomies, may be necessary to reestablish normal renal function.

## 9 Comment

The majority ureteral injuries are associated with pelvic surgery. The gynecologic surgeon must become familiar with the anatomy of the abdominal and pelvic ureter and the locations where it is most susceptible to injury. Clearly, prevention is the best defense against ureteral trauma. But when there is damage, initial endourological management offers a safe, minimally invasive option in patients with bilateral ureteric

injury. The placement of ureteric stents allows recovery from a large and traumatic procedure. In many cases, ureteric stenting offers a definitive treatment and avoids further extensive and challenging procedures [27].

When urinary complications do occur, it is important to deal with the injury effectively and possibly with an early consultation with an experienced colleague or urologist. It is important to be honest and straightforward in attitude and speech with patients and relatives, explaining clearly what happened and proposing the suitable solution [28, 29].

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